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Lecture No. 17-19

"Alternating Voltage"

Alternating voltage

Generation of alternating voltage :

Alternating voltage may be generated by rotating a coil in a magnetic field as shown in fig. 1 or by rotating magnetic field within a stationary coil as shown in fig. 2 .

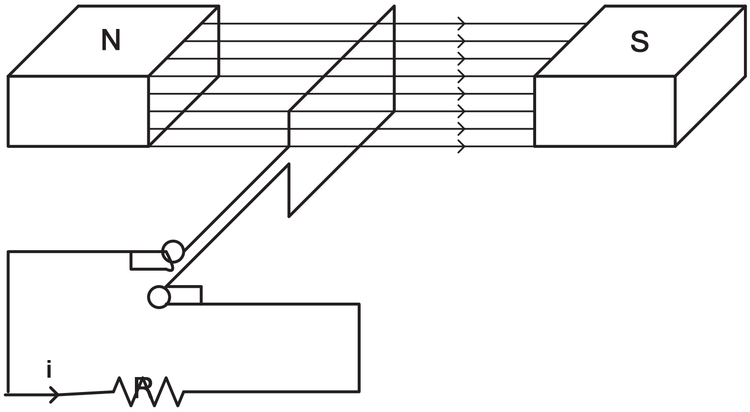

Fig 1

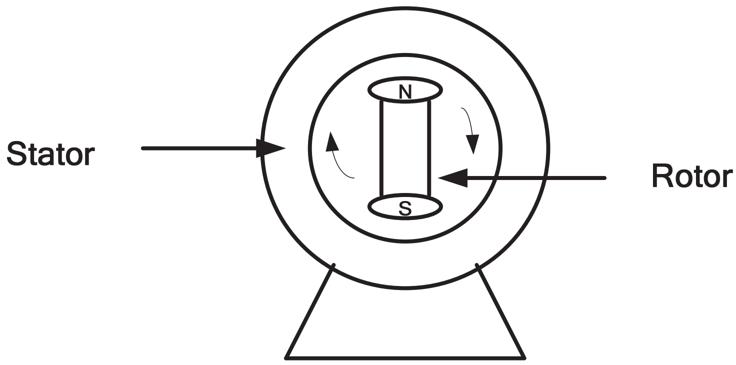

Fig. 2

The value of voltage generated depends upon the followings :

1. **Number of turns of coil .**
2. **Strength of the magnetic field .**
3. **Speed of rotation .**

Equation of the alternating voltage and current :

Consider a rectangular coil having (N) turns and rotating in a uniform magnetic field with an angular velocity of (w) as shown in fig. 3 .

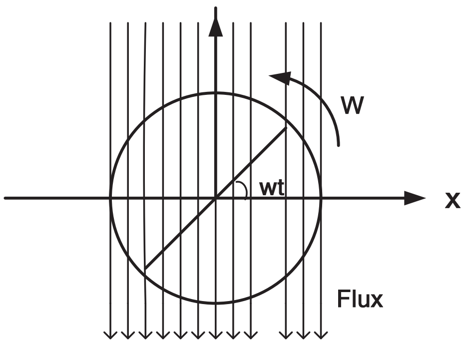

Fig. 3

Maximum flux (Φ_m) is linked with the coil when its plan coincidens with the x – axis . For different values of (wt) the effective component is

$$\Phi = \Phi_m \cos wt$$

According to Faradays laws , the instantaneous value of the induced e.m.f is

$$e = - \frac{d}{dt} (N \Phi)$$

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$$e = -N \frac{d}{dt} (\Phi_m \cos wt)$$

$$e = -N \Phi_m w (-\sin wt)$$

$$e = w N \Phi_m \sin wt$$

e has maximum value when wt = 90 , since sin 90 = 1 .

$$E_m = w N \Phi_m$$

Therefore , for resistive load :

$$e = E_m \sin wt$$
$$i = I_m \sin wt$$

it is seen that the induced e.m.f varies as a sin function with wt as shown in fig. 4 .

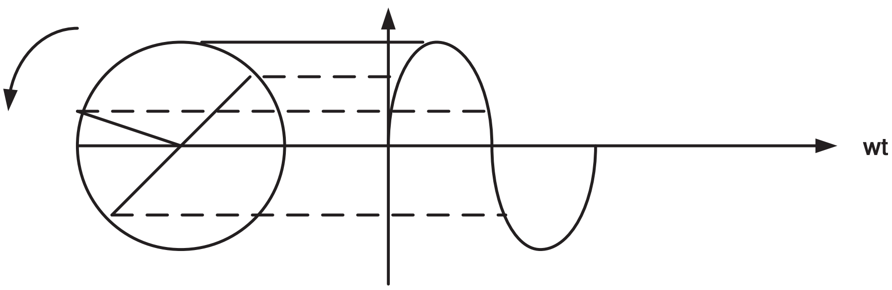


Fig. 4

Root – Mean square value (r.m.s value) :

It is also known as the effective value of the voltage or current . There are two methods for finding this value .

1. Mid – ordinate method : In this method , the wave is divided to n equal intervals

$$V_{r.m.s} = \sqrt{\frac{V_1^2 + V_2^2 + V_3^2 + - - - - - + V_n^2}{n}}$$

2. Analytic method :

$$V_{r.m.s} = \sqrt{\frac{\int_0^T v^2_{(t)}\, dt}{T}}$$

$$I_{r.m.s} = \sqrt{\frac{\int_0^T i^2_{(t)}\, dt}{T}}$$

In case of symmetrical sinusoidal wave :

$V_{r.m.s} = 0.707 \; V_m$
$I_{r.m.s} = 0.707 \; I_m$

<u>Example</u> : Find the effective value (r.m.s value) of the waveform shown in fig. 5 .

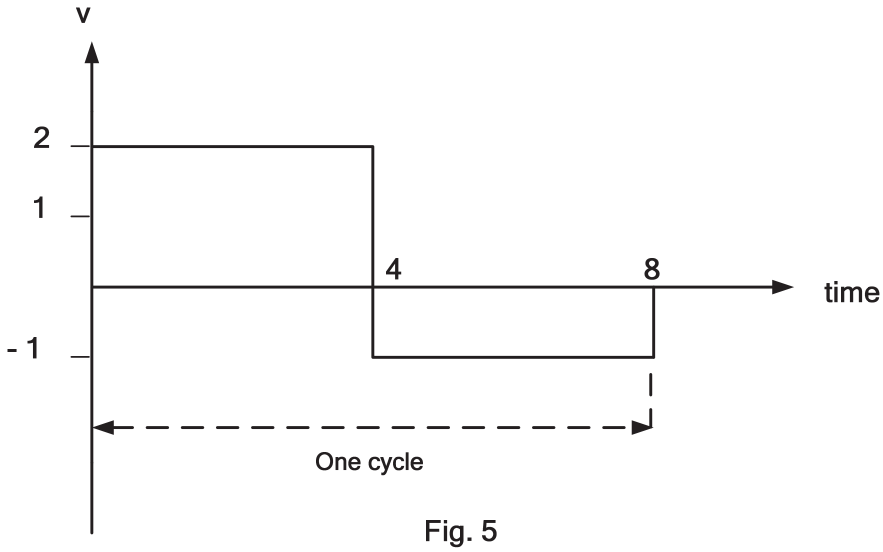


Fig. 5

$$V_{r.m.s} = \sqrt{\frac{(4^2 \text{ x } 2) + (-1) \text{ x } 4}{8}} = 1.58 \text{ v}$$

The average value :

The average value of alternating current is expressed by the steady current which flow through any circuit .

$$I_{av} = \int_0^T \frac{i_{(t)}\, dt}{T}$$

$$V_{av} = \int_0^T \frac{V_{(t)}\, dt}{T}$$

$$\text{Average value} = \frac{\text{Algebraic sum of areas}}{\text{Length of wave}}$$

Example : **Find the average value of voltage for the wave in fig. 5 .**

$$V_{av} = \frac{(2 \times 4) + \{(-1) \times (8 - 4)\}}{8} = 0.5 \text{ v}$$

In case of symmetrical sinusoidal wave :

$V_{av} = 0.637\ V_m$
$I_{av} = 0.637\ I_m$

Form factor : **It is defined as the ratio between the r.m.s value and the average value .**

$$K_f = \frac{\text{r.m.s value}}{\text{average value}}$$

Where K_f is the form factor .

In case of symmetrical sinusoidal wave :

$$K_f = \frac{0.707\ V_m}{0.637\ V_m} = 1.11$$

$$K_f = \frac{0.707\ I_m}{0.637\ I_m} = 1.11$$

Vector representation of alternating voltage and current :

Alternating voltage and current can be represented by a vector . A vector quantity is a physical quantity which has magnitude as well as direction . The length of the line represents the magnitude of alternating quantity , the inclination of the line with respect to some axis of reference gives the direction in which the quantity acts .

Phase difference :

For two or more alternating quantities , one quantity may leads or lags the other quantities by definite angle . A leading alternating

quantity is one which reaches its maximum or zero value earlier as compared to the other quantity .
Similarly , a lagging alternating quantity is one which reaches its maximum or zero value later than the other quantity . Fig. 42 shows alternating quantities (A) and (B) , in this figure , the alternating quantity (B) leads alternating quantity (A) by angle θ .

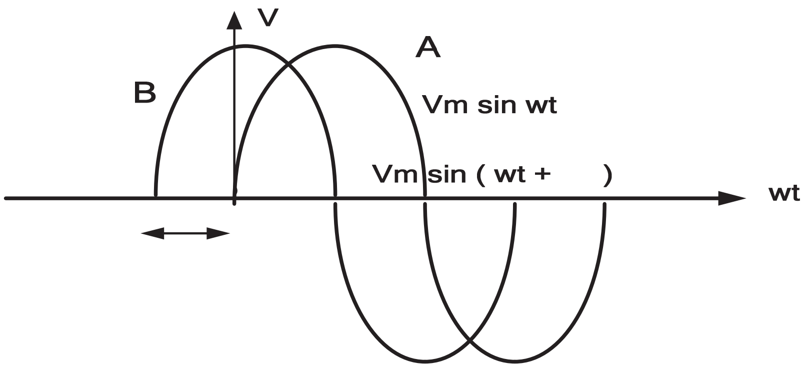
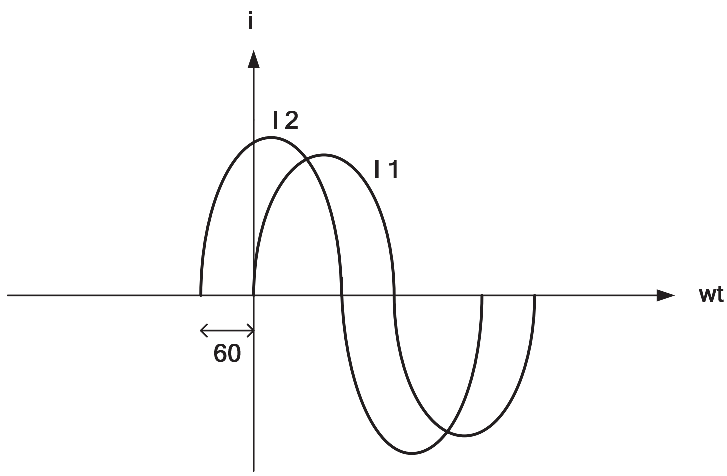


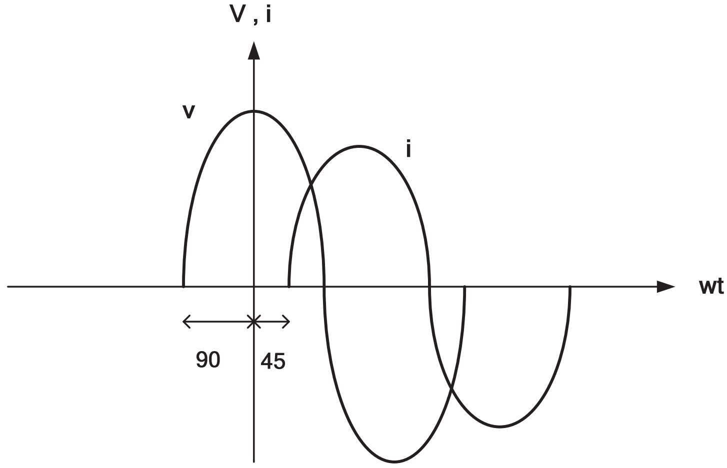
Fig.42

<u>Example</u> : Draw the waveform for the followings :

A - $i_1 = 7 \sin wt$, $i_2 = 10 \sin(wt + \pi/3)$



B - $v = 70 \sin(wt + 90)$, $i = 50 \sin(wt - 45)$


V , i
v
i
wt
90
45